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This paper presents a new approach to the measurement of change within human systems (individuals, groups, organizations, communities). It is reported as being a more realistic and accurate approach than the use of simple raw-score change, easier to calculate than the analysis of co-variance and other procedures designed to equalize the effects of individual difference in pre-scores, and more able to provide meaningful comparisons between cases. The approach is called "percentage gain" and is computed by taking the percentage that the actual raw score point change is, of the number of points available between the pre-score and the highest possible scores. Percentage gain scores were calculated for a sample of 196 workshop students and compared with simple raw change scores in several statistical analyses. (Author)

PERCENTAGE GAIN: AN ALTERNATIVE APPROACH TO THE MEASUREMENT OF CHANGE

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This paper presents a new approach to the measurement of change within human systems (individuals, groups, organizations, communities). It is reported as being a more realistic and accurate approach than the use of simple raw-score change, easier to calculate than the analysis of co-variance and other procedures designed to equalize the effects of individual differences in pre-scores, and more able to provide meaningful comparisons between cases. The approach is called percentage gain and is computed by taking the percentage that the actual raw score point change is of the number of points available between the pre-score and the highest possible score. Percentage gain scores were calculated for a sample of 196 workshop students and compared with simple raw change scores in several statistical analyses.

Introduction to the Problem

Researchers, who have attempted to compare the amounts of change achieved by a number of persons along a particular dimension over a period of time, are well aware of the fact that individual differences in starting positions confuse the meaning and contaminate the validity and fairness of the comparisons. The problem is one of sufficient magnitude to stop researchers in the tracks of their own research and draw them into the quest for more accurate, defensible and less complex methods than seem currently available for managing the measurement and comparison of individual growth.

Thorndike[3] initially called attention to this problem in 1924, Diederich[1] carefully summarized the issues involved in 1956, and Harris[2] organized a scholarly review of the problem in a 1963 text.

A major concern is that, in the more customary methods of analysis of pre- and post-scores on achievement-type inventories, the largest average gains are made by low starters and the smallest average gains are made by high starters. The phenomenon of the "regression of post-scores toward the mean" is cited as one causative factor, and the greater difficulty facing the high pre-scorer as compared to the low pre-scorer is cited as another.

Essentially, the question behind the problem is: When measuring any kind of change in a person, where there is a pre- and a post-assessment, how can the change be calculated so that the individuality of the person's pre-score is accounted for and yet his change can be represented in terms which allow for a fair comparison to changes in others?

Several statistical procedures for minimizing or eliminating the impact of pre-score differences on the measurement and comparison of change have been developed. Examples of these are: analysis of co-variance; regression analysis; arranging pre-scores into separate populations of high, middle and low and then analyzing change within these separate populations; initial testing for significance of difference between pre-scores to establish possible non-difference in starting positions. Some researchers, finding these procedures either too laborious or complex for the goodness of the consequences or too inappropriate for their own purposes, choose not to deal with the issue of pre-score contamination at all. Instead, they may settle for simple gain in raw score points as their measure of change.

This article suggests one more approach to the measurement of individual change. It is a non-complex procedure which employs the post-score in relation to the distance between the pre-score and the highest possible score. It appears to yield a more meaningful assessment of individual change and allows for a more accurate comparison of changes made by different persons. This statistic, which the authors call Percentage Gain, responds to such questions as: Where the highest possible score is 100, did the person who began at 15 and then gained ten points achieve an equal, greater, or lesser amount than the person who began at 70 and then gained ten points? Did the person who began at 20 and then gained eighty points achieve an equal, greater or lesser amount than the person who began at 80 and then gained twenty points? What about the person who began at 40 and gained thirty points as compared to the person who began at 50 and gained twenty-five points? Employing Percentage Gain as the statistic, the answer to the first question is "lesser," and the answers to both the second and third questions are "equal." This is so, since change, here, is a measure of the degree to which each person moved toward complete or 100% gain, considering each person's own individual initial score and the percentage of the distance his post-score covered between his initial score and the highest possible score. Each person has, in a sense, his own "track to run," and the size of the units of gain are not the same for everyone but are determined by the person's own starting position. Thus, the person who entered with a score of 15 and

gained ten points covered only 11.7% of his remaining eighty-five points. The person who entered with a score of 70 and gained ten points covered 33.3% of his remaining thirty points.

Whether or not the use of Percentage Gain actually yields findings which are significantly different from simple gain scores is considered in the next section of this paper. The data used to compare these two methods for measuring change were collected from 196 adults immediately before and after their attendance at a six-day social science summer workshop. The same instrument, requesting the subjects to respond to twenty positional statements and having a lowest possible score of 20 and a highest possible score of 160, was administered before and after the workshop.

While this article focuses on the measurement of change within individual persons, Percentage Gain has also been employed by the authors to assess change within larger human systems, e.g., groups, organizations and communities.

Statistical Investigation of Percentage Gain

When the final score for an individual exceeded his initial score, the percentage gain score was defined as:

$$P.G. = \left(\frac{X_2 - X_1}{R_p} \right) 100$$

where X_2 = final score
X_1 = initial score
R_p = highest possible score minus - initial score (maximum possible gain)

When the final score was less than the initial score, percentage gain was defined as:

$$P.G. = \left(\frac{X_2 - X_1}{R_n} \right) 100$$

where X_2 = final score
X_1 = initial score
R_n = initial score minus lowest possible score (maximum possible loss)

In the immediately above case, a percentage gain score would be negative. The total range for percentage gain in both negative and positive directions would be -100 to +100. A frequency distribution of these scores would be expected to exhibit negative skewness since the majority of changes would be in a positive direction.

Pre- and post-test scores were employed to compute (a) percentage gain scores, and (b) simple change scores for each of the 196 students in the workshop. Simple change was defined as the actual difference between post- and pre-test scores.

That percentage gain scores do differ from simple change scores was evident upon examination of the data. For instance, nine of the workshop students had simple change scores of 15 points. The percentage gain scores for the same nine students ranged from 52 to 12, specific scores being 52, 31, 29, 26, 25, 23, 22, 18, 12. Since percentage gain scores are defined as per cent of possible change, higher per cent change was associated with higher initial score. Thus, the student with a percentage gain score of 52 had a

pre-test score of 146, and the student with a percentage gain score of 12 had a pre-test score of 110.

Further evidence of the difference between the two types of scores is provided when all the percentage gain scores are rank-ordered and all the simple change scores are rank-ordered, the two ranks for each score are listed side-by-side, and then the differences between all the paired ranks are calculated and laid out for observation. Table 1 presents a summary of how much and how many of the 196 paired ranks differed from each other. As indicated, a person's achievement in comparison to the achievements of others can vary greatly depending on whether the achievement is measured by percentage gain or simple change.

TABLE 1

DIFFERENCES BETWEEN THE RANKS OF PAIRED SIMPLE CHANGE AND PERCENTAGE GAIN SCORES

Sizes of Differences Between Paired Ranks	No. of Paired Ranks Having that Difference	% of Paired Ranks Having that Difference
0	26	13%
1-2	35	18%
3-7	34	17%
8-12	30	15%
13-19	32	16%
20-26	20	10%
28-41	12	7%
44-68	7	4%
	N = 196	100%

The transformed scores were compared using several statistical analyses. Table 2 presents rank order correlation coefficients for percentage gain and simple change scores. Although, as already

indicated, there were many discrepencies in percentage gain scores among individuals with the same simple change, a surprisingly high rank order correlation of +.953 was found for the total group. A partial explanation of the high correlation might be found in the fact that positive scores on one variable were always associated with positive scores on the other, the same perfect relationship holding for negative scores.

To examine more closely the nature of this relationship, the rank orders of the simple change scores were split into two groups of high changers and low changers. Then correlations with ranks of the associated percentage gain scores were calculated. As indicated in Table 2, the correlations were still very high within the two groups--+.956 for the high changers and +.902 for the low changers. The nature of this relationship was then examined even more closely by splitting the rank orders of the simple change scores into four groups of highest to lowest changers and then comparing them to the ranks of the associated percentage gain scores. This latter arrangement, as also indicated in Table 2, showed some differences between the sizes of the correlations within the four groups. The highest correlation (+.988) actually occurs within the highest changer group, the next highest correlations (+.659 and +.675 occur within the two middle changer groups, and the lowest correlation (+.540) occurs within the lowest changer group. While all correlations were statistically significant ($<$ .01), they decreasingly accounted for all factors involved—from <u>97.6%</u> (.988 x .988) to <u>29.2%</u> (.540 x .540).

TABLE 2

RANK ORDER CORRELATIONS BETWEEN SIMPLE CHANGE SCORES AND ASSOCIATED PERCENTAGE GAIN SCORES

Change Level and Size of Population		Rank Order Correlation
Total (196)		.953
High Changers	(98)	.956
Low Changers	(98)	.902
Highest Changers	(49)	.988
Middle High Changers	(49)	.659
Middle Low Changers	(49)	.675
Lowest Changers	(49)	.540

Table 3 presents correlation coefficients which indicate the nature of the relationships of percentage gain and simple change scores to pre- and post-test scores.

TABLE 3

CORRELATIONS BETWEEN PERCENTAGE GAIN, SIMPLE CHANGE AND PRE- AND POST-TEST SCORES (N = 196)

Variable	Pre-Test	Post-Test
Percentage Gain	-.39	.63
Simple Change	-.61	.46

Both percentage gain and simple change scores were associated negatively with pre-test scores and positively with post-test scores. However, the relationship with post-test scores was somewhat higher for percentage gain than for simple change. Simple change tended to exhibit relatively higher relationships with pre-test scores.

The means and standard deviations of the percentage gain scores and the simple change scores are given in Table 4. Also given are the coefficients of variation obtained by the formula: C.V. = $\sigma/\bar{x}(100)$. Both mean and standard deviation were larger for the percentage gain than for simple change scores. Because of the difficulty of comparing standard deviations based upon different units of measurement, the coefficients of variation also are reported. The coefficient tends to place different standard deviations on a similar scale. The computed coefficient of variation was less than 100 for percentage gain scores, but above 100 for simple change scores. Thus, it appears that the range of variation between scores within a distribution of percentage gains is smaller than within a distribution of simple changes.

TABLE 4

MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION FOR PERCENTAGE GAIN AND SIMPLE CHANGE SCORES (N = 196)

Variable	Mean	Sigma	C.V.
Percentage Gain	26.06	21.80	84
Simple Change	14.80	16.10	109

Skewness and kurtosis of the percentage gain and simple change scores were investigated using Fisher's k statistics. The resulting statistics may be referred to the standard normal curve. Values are shown in Table 5.

TABLE 5

SKEWNESS AND KURTOSIS COEFFICIENTS FOR PERCENTAGE GAIN AND CHANGE SCORES (N = 196)

Variable		Values	P
Percentage Gain:	Skewness	-1.50	N.S.
	Kurtosis	.02	N.S.
Simple Change:	Skewness	-2.68	.05
	Kurtosis	2.17	.05

As may be anticipated, negative skewness was found for both percentage gain and simple change scores. For simple change scores the skewness was statistically significant, as was the kurtosis, the distribution being flat-topped. There is some suggestion that the percentage gain transformation has a normalizing influence.

The 196 workshop students were subdivided into two groups based on age categories: (a) under 40; and (b) over 40. The object was to investigate the extent to which percentage gain and simple change scores would differentiate the age groups in tests of significance. Table 6 presents t-ratios for mean differences between the groups.

As indicated in Table 6, the percentage gain scores produced a significant mean difference, whereas the simple change scores did not, the t-ratio of the percentage gain mean difference being significant at the .05 level of probability. Thus, in this particular case an investigator would have been led to different conclusions on the null hypothesis (equal means) depending upon the manner in which the measures were computed.

TABLE 6

MEANS AND t-RATIOS FOR TWO AGE GROUPS ON PERCENTAGE GAIN AND SIMPLE CHANGE SCORES (N = 196)

Variable	Statistic	Age Group a 20-39 yrs. (N = 105)		Age Group b 40-50+ yrs. (N = 91)	P
Percentage Gain	Mean	30.12		23.05	
	t-Ratio		2.26		.05
Simple Change	Mean	17.19		12.99	
	t-Ratio		1.80		N.S.

<u>Conclusion</u>

In all, percentage gain represents another alternative available to researchers when they are attempting to assess growth and change in human systems. Based upon the analysis of the data in this study, the following observations can be made regarding the behavior of the percentage gain scores.

1. Persons achieving the very same raw score gains varied widely in their percentage gain scores. Thus, when a set of scores were rank-ordered on a percentage gain basis, they assumed different positions than when they were rank ordered on a simple change basis.

2. Percentage gain scores were more highly correlated with post-test scores, and simple change scores were more highly correlated with pre-test scores.

3. The range of variation between scores within a distribution of percentage gains was smaller than within a distribution of simple changes.

4. The use of percentage gain appeared to have a normalizing effect upon a distribution of scores.

5. While the use of simple change may penalize the high starters by standardly reducing their gains below that of the low starters, the use of percentage gain does not.

6. Analysis of data by percentage gain and simple change can produce different interpretations of that data.

References

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